

Understanding airborne fertilization of oceanic ecosystems using satellite products

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There is a long-standing hypothesis that airborne mineral aerosols deposited into the ocean bring needed nutrients such as iron to nutrient-limited ocean ecosystems and cause biological responses to that fertilization. We have engaged in an interdisciplinary study to test that hypothesis on a basin wide scale using various satellite and assimilation system data. The challenge from the atmosphere side is to identify dust events and determine deposition fluxes into the water. The challenge from the ocean side is to monitor ecosystem response to these events, when such responses may take the form of anomalous phytoplankton chlorophyll concentrations, biomass, physiology, and/or fluorescence quantum yields, each linked to different biologic conditions. As a pilot study we have focused on specific volcanic eruptions with ash plumes extending over nutrient-limited ocean waters. We use MODIS observations to track the extent of the ash and MERRA reanalysis products to quantify deposition into the water. The pattern of the ash dispersion, both temporally and spatially, is linked to MODIS observations of anomalous oceanic parameters. Mixed layer depths did not change during the events, suggesting therefore that the observed ecosystem changes were a consequence of atmospheric deposition rather than physical oceanic processes. Expanding upon this pilot study, we have considered the entire north Pacific basin and the years 2002 to 2017, producing a climatology of dust transport over the Pacific and corresponding ocean ecosystem anomalies.

The primary satellite instrument used by both atmospheric and oceanic scientists has been MODIS, with assistance in the atmosphere by the MERRA-2 reanalysis data. Other similar studies have also made use of CALIPSO to characterize dust. Of high interest to this interdisciplinary team is the potential that multi-angle polarimetry (MAP) might add to such a study, for both the characterization of the airborne nutrients and also the characterization of the ocean biological response. There have been few ocean biology studies using POLDER and other incidental indications that if atmospheric correction could be applied properly to achieve the polarization signal at the ocean surface interface, new opportunities will emerge for characterizing the ocean response to airborne fertilization.

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